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ABSTRACT

This teacher's guide suggests activities that provide a wide range of opportunities for children in grades 1-7 to plan, direct, and carry out experiments with seeds and the growth of plants. Photographs are provided and methods discussed for guiding students in exploring the growth of seeds, the effect of dark on growth, factors causing plants to bend as they grow, cutting plants during growth, and effects of salt, temperature, and insects on growth. (CS)

teacher's guide for

starting from seeds

Elementary Science Study

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The Starting from Seeds Unit
Teacher's Guide for Starting from Seeds

Related Units
Growing Seeds
The Life of Beans and Peas

ISBN 07-017726-0

Preface

The Elementary Science Study is one of many curriculum development programs in the fields of science, social studies, and mathematics under preparation at Education Development Center, Inc. EDC (a private nonprofit organization, incorporating the Institute for Educational Innovation and Educational Services Incorporated) began in 1958 to develop new ideas and methods for improving the content and process of education.

ESS has been supported primarily by grants from the National Science Foundation. Development of materials for teaching science from kindergarten through eighth grade started on a small scale in 1960. The work of the project has since involved more than a hundred educators in the conception and design of its units of study. Among the staff have been scientists, engineers, mathematicians, and teachers experienced in working with students of all ages, from kindergarten through college.

Equipment, films, and printed materials are produced with the help of staff specialists, as well as of the film and photography studios, the design laboratory, and the production shops of EDC. At every stage of development, ideas and materials are taken into actual classrooms, where children help shape the form and the content of each unit before it is released to schools everywhere.

Acknowledgments

In 1966, Roger Payne began work on a unit he called *Bending Plants*. In the course of teaching an early version of the unit, I found that many children (even seventh graders) were interested in other aspects of plant physiology as well.

I would like to thank Cornelia Voorhees, who observed three developmental classes that I taught in Belmont and Concord, Massachusetts; and Virginia Strong and Stephen Manning, who taught classes (which I observed) in Watertown, Massachusetts. Ginny Strong was also extremely helpful with suggestions for activities and for improving the manuscript.

STARTING FROM SEEDS was trial taught in the spring of 1969 in about 25 schools across the country. Suggestions from trial teachers led to changes in the manuscript for this edition.

The classroom photographs are by Major Morris, and the remaining photographs are by Joan Hamblin. Adeline Naiman edited the manuscript, and Nancy Weston oversaw the production of this *Guide*.

Mary S. Gillmor

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Introduction

Try to help the children move on to new experiments by asking them questions and occasionally suggesting a method of investigation. Planning for some experiments may involve a fairly large group. Other experiments may be possible for an individual to carry out alone. If several people do the same experiment, they may not all get the same results. Can they figure out why not? What did they do differently? Can they repeat the experiment so that they will all get the same result?

Your students may enjoy viewing the two film loops made for the Elementary Science Study unit GROWING SEEDS: *Bean Sprouts* and *Plant Growth—Graphing*.*

Grade Level and Scheduling

The unit has been taught with children as young as first graders and as old as seventh graders. Some of the activities described will be possible only with older children.

Plan to start the unit at a time when a vacation will not interrupt the work immediately. Many experiments require observation during the first or second week of a plant's growth.

Thirty to forty-five minute classes, three times a week, have worked best, though a few minutes are needed every day for watering the plants. The unit can also run concurrently with other activities, since there may not be things of interest for all children to do every day. In fact, you may want to have only a small group of interested children working on this unit at any one time.

*Available from Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011.

Materials

basic materials

1–2 lb unpopped popping corn* 1–2 lb dried kidney beans*	These are readily available by the pound in grocery stores, and they grow quickly. Other seeds sold in grocery stores by the pound can be substituted.
5 lb vermiculite*	This is available in large quantities in garden-supply stores. Vermiculite is easier to manage than soil, molds less easily, and isn't as heavy. Soil, gravel, sand, perlite, or even sawdust can be substituted.
containers in which to grow plants (small plastic dishes, paper cups, rinsed-out milk cartons cut down to appropriate size if necessary)	Almost anything that will hold water will do. It is best to avoid metal containers, since they may rust and then kill the plants.
2–lb coffee cans, quart juice cans, cardboard boxes, or other opaque containers large enough to fit over the plants and the pots in which they are growing	These are for experiments with no light. Closed cupboards, closets, or other dark spaces can be used instead.
pitchers or large milk cartons	You will need these for watering the plants.
classroom supplies (paper, pencils, notebooks, masking tape, paper towels, crayons, mop, dustpan and brush)	

*Large quantities of seeds and vermiculite are recommended because they encourage experimentation. If a child is given only two or three seeds, he will be hesitant to try different ideas. With more, he has a better chance of sprouting and growing seeds successfully.

other materials you may need

soil

sand

rocks

colored cellophane

construction paper

other seeds: oats, varieties of dried beans, Indian corn, sunflower seeds (Most flowers and many ordinary garden plants take as long as three weeks to sprout and so are not ideal for classroom growth. They are also *much* more expensive.)

plastic wrap

plastic bags

glass jars with tight tops

magnifying glasses

low-power microscopes (10×–40×)

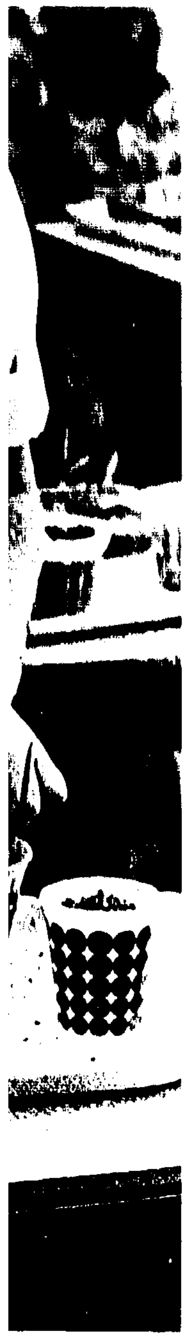
plastic tubes

vinegar, liquid bleach, ammonia, detergent, tea, coffee, salt water, cologne (See pages 22 and 24.)

string

$\frac{1}{4}$"–$\frac{3}{8}$" doweling

You will also need considerable shelf, windowsill, or table space. It is a good idea to begin fairly early to collect containers of assorted sizes and shapes, string, doweling, and boxes. A "junk box" in a corner of the room can be extremely useful. Often an interesting object will give someone an idea for an experiment.



Gardening Problems

mold

The children will find, after some experimentation, that the seeds they are using need to be damp in order to sprout. The seeds should not be left soaking, since they will rot if there is too much water. Have the children throw away rotting and molding seeds and the surrounding vermiculite. Give them more seeds and vermiculite, and *let them start again.* They will learn much more about the plants and their requirements if they come to recognize overwatering (or underwatering) by themselves.

However, if your students seem to be having an excessive amount of trouble sprouting seeds that are free of mold, suggest that they can try sterilizing the outsides of the seeds before they plant them. Many commercial fungicides are available for sterilizing seeds, but a weak solution of liquid chlorine bleach will work equally well. Mix eight parts of cold tap water to one part of liquid bleach. Put the seeds in this mixture, swirl them around, and take them out right away. It is not necessary to rinse the seeds before you plant them.

drying out

Many classrooms, especially in winter, provide a very poor environment for plants. Seedlings, particularly, cannot survive the severe drying which often occurs over the weekend. One way to alleviate this problem is to construct small greenhouses for the young plants. A plastic bag placed over a pot of plants will keep moisture in, while allowing plenty of air and sunlight to get through.

Gardeners

In any class, there will always be individuals who simply cannot bear to do anything to their plants that might possibly hinder growth, even in the interest of finding out things. These children can become the class gardeners. They can try to raise plants through a complete life cycle. This will be difficult with corn (unless you can plant the seeds outdoors) but quite possible with beans and peas. (See the Elementary Science Study unit THE LIFE OF BEANS AND PEAS.*) Children in one trial class grew plants outdoors in a cold frame with great interest and success. Directions for making a cold frame can be found in most gardening books.

As time goes on, some of these gardeners will, of course, move on to experiments. As they watch their plants grow, questions will come up which they will want to answer. Perhaps they will be willing to sacrifice some of their plants to find the answers—or perhaps they will find a question or a way of answering a question that will not in any way hurt the plants. In trial classes, teachers have often encouraged children to raise at least two sets of plants—one to watch growing and the other to use for experiments. This is a good way of coping with the problem, but it does take more shelf space. Of course, simple conscientious observation of healthy growing plants can be of great value, for there are many worthwhile questions which children can answer without damaging their plants.

*Available from Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011.

A Way to Start

This unit will be most valuable if you can allow the children to set about trying to answer their own questions right from the beginning. You may find it helpful, however, to get things started by asking a provocative question. A successful opening question in trial classes has been: "What will happen if we plant these seeds in the dark?" Because they've heard about light and photosynthesis (or simply because they've heard that plants need light), many children say that seeds will not grow at all in the dark. Others reason that seeds must be able at least to sprout in the dark; otherwise, "How would they sprout underground?" Do not bring this up unless the children themselves do. In the end, the only way to find out what happens is to try it.

Some of the children will probably want to plant some seeds in the light as well as in the dark. If they do this, they will then have something with which to compare their dark-grown seedlings. If they don't, they will learn firsthand the need for comparison plants.

As the materials list indicates, you will need very few things to start this unit. If you want to begin with the question of growth in the dark, you should assemble the following for a group of 30 children:

- 1 lb unpopped popping corn
- 1 lb dried kidney beans
- 2 lb vermiculite
- at least 30 containers in which to grow plants
- 30 opaque containers to cover growing plants and pots

Later on, you will need more seeds, vermiculite, containers, and many other odds and ends.

Children can set up their containers and plant their seeds independently. If you place the bag of vermiculite in a cardboard box, spillage will be less of a problem. Some of the children will probably wonder what vermiculite is. In one class, the children went to the library and found out.

Have each child take about a dozen seeds. A large number of seeds will assure everyone of several healthy plants, and the class will have lots of plants to compare. Perhaps some children will want to see whether their plants grow better with a few or many in a container.

In trial classes, children have begun growing just one type of seed at first and have later started growing other kinds. Some children will probably want to bring in seeds from home. If you have space for more containers, this can be very valuable, for the children will have more types of plants to compare. *Can they tell which plants came from the same type of seed?*

As the children plant the seeds, questions arise:

How deep do you plant them?
Is this enough water?

If you restrain yourself from giving answers to these questions, some of the children may go on to further experiments:

Do deeply-sown seeds grow better than seeds that are planted close to the surface?
How little water will allow the seeds to sprout?
Will the seeds sprout under water?

Encourage interested children to explore these side questions. Similar opportunities for independent investigations will arise throughout the unit. Once the children have started this kind of inde-

pendent work, your job, as teacher, will be to encourage, to question, to comment, and to supply needed materials.

An important aspect of this is helping children to think about all the variables involved in an experiment. Suppose a child has grown some plants in the dark. He tells you that plants grown in the dark don't get green. Is he sure it is lack of light that makes them pale? Perhaps these plants are naturally pale. If he or someone else has grown some of the same plants in the light and they are green, he can be nearly certain that it is the darkness that makes them pale.

How Dark Is Dark?

The question "How dark is dark?" often comes up. If it doesn't, you might raise it. Some children may think that a corner of the room shaded from the window is dark; others may suggest a closet or the space behind the books on a bookshelf. Others will undoubtedly suggest using the coffee cans they have brought in or covering the plants with construction paper. Let the children try different places and methods, but make sure that someone is growing his plants completely in the dark (under a coffee can, for instance). You may have to do it yourself. *Are there differences between these plants and those grown in very dim light?*

You may want to discuss "darkness" at some length with the children. Do they think they can see anything if it is really dark? In one fifth grade, the children were sure that you could still see a little, particularly if the thing you were looking at was yellow or white.

The teacher then brought in some black paper Halloween bags and a number of small blocks of different colors. She asked the children to put a block in each bag, hold the bags tightly against their

Greenness

As the seeds in the dark sprout and grow and the children compare them with similar seeds sprouted in the light, interesting observations will be made. Soon (in about 10 days) the light-grown plants will be a rich green color, while the dark-grown ones will remain pale yellow. Children have often tried reversing the plants—putting the green ones in the dark and the yellow ones in the light.

What happens? What determines whether the plants get green? Will just a little light do, or do the plants have to be in full sunlight? Will the light from a flashlight be enough? Does the color of the light make a difference? (A child could put his dish of sprouting seeds in a cardboard box, such as a shoe box, and cover the open top with colored cellophane.) *What if just one leaf is kept in the dark? Does that leaf get green with the rest of the plant or does it stay pale?*

They Grow Faster

Do the children notice anything else about the dark-grown plants besides their color? Bean and pea plants grown in the dark tend to become very spindly. Can the children think of any reason why it would be advantageous for a plant to grow more quickly in the dark than in the light? *Which plants look more healthy? Which seem stronger? Which live the longest?*

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Some Possible Paths

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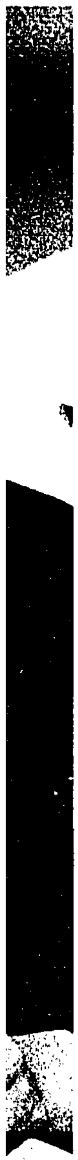


Bending Plants

If the children do get into experiments with plants grown in small amounts of light or if a window- or lamp-lit area is much brighter than the rest of the room, they may notice that some of the plants seem to bend toward the light. *If the plant is turned around, will it bend back again toward the light? Is the plant really just bending, or is it growing toward the light?* Some children have become very interested in bending plants and have gone on to do more detailed experiments. One group covered up seedlings with a coffee can in which a window was cut. They tried different colors of cellophane in the window to see whether the seedling would grow toward the different colors of light.

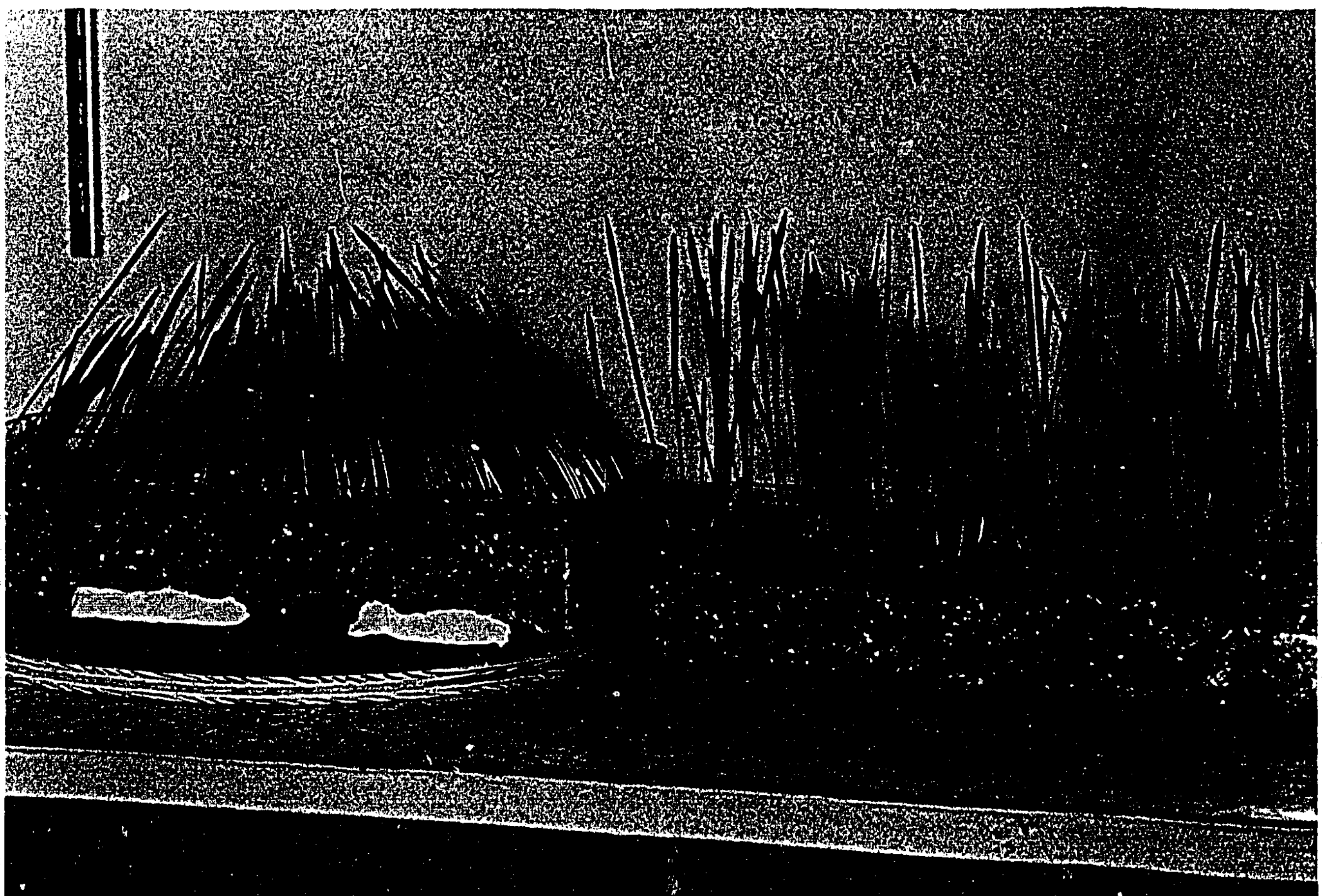
Growing Things Upside Down

Another good opening might be to ask, "Does it matter which way you plant a seed? What if it is planted upside down?" Children in trial classes have done many different experiments in an effort to find out. Often this question has led them to ask what happens if the young seedling is turned upside down after it has started growing. Some have even tried tipping over older plants to see if they would grow back up again.

Some seventh graders became interested in finding out how long it took for an oat seedling to "know" that it had been turned on its side. They grew some seedlings and then tipped them on a side for varying lengths of time during one day before turning them back upright. The next day they found some plants with bends in them, which indicated that they had grown sideways for a while. Some plants showed kinks after being tipped for only half an hour.

Spinning Plants

If you can find an old phonograph turntable, someone might try growing some seedlings in a container fastened to the turntable and kept rotating for several days. *Does a slow speed produce a different effect than a fast speed? What if you start the turntable after the seeds have sprouted? What if you stop the turntable after the plants have grown about an inch?*



Seeds and Seedlings

Dissections and comparisons of various seeds can be of interest. In trial classes, children compared the insides of soaked oats and beans. They found that both had a fairly large proportion of "stuff" that got soft after very long soaking and that gradually diminished as the young plant grew. Children also compared the growth rates of the young seedlings and noticed that the oat seed sent down several little inconspicuous roots. The stem often sprouted before the root. The original oat seed stayed underground. The bean plant, on the other hand, always sprouted a single thick root first. A number of children who had grown oats exclusively for some time confused the bean root with the oat stem at first and commented, "It's growing the wrong way!" They soon realized, however, that since it was growing downward, the structure they were seeing was a root, not a stem. They were fascinated with the way some of the bean plants carried the remains of their seeds high in the air as they grew, and they noticed how different the bean leaves were from the oat leaves.

If you have other plants in the room, if the children bring in other seeds to plant, or if you can go on a field trip around the school grounds or to a park, the children can look for similarities and differences among the plants. *Which plants look more like corn plants? Which, more like bean plants?* If you restrict the discussion to leaf type and general structure, there will be plenty to observe. Corn belongs with the grasses (monocots), while beans are dicots and have two seed leaves. (For a more detailed discussion of the structure and life cycle of beans, see the Elementary Science Study unit THE LIFE OF BEANS AND PEAS.*)

*Available
Hill Book
Mancheste

Cutting Off Parts of Plants

Some children may want to see which parts of their plants are dispensable. *Can one of their plants live without its roots? For how long . . . ?*

Cutting off the remains of the seed after it has sprouted can be an interesting project. *What happens to the seed as the plant grows? What function does it fulfill? Will a very young seedling survive if its "seed" is removed? What about an older plant? What about plants grown in the dark? How long will they survive without the seed?*

In a trial class, students discovered that if they cut the leaves off a bean plant above the place where the seed had been when it came up, new leaves would often grow out of this place. If they cut below this place, the plant always died.

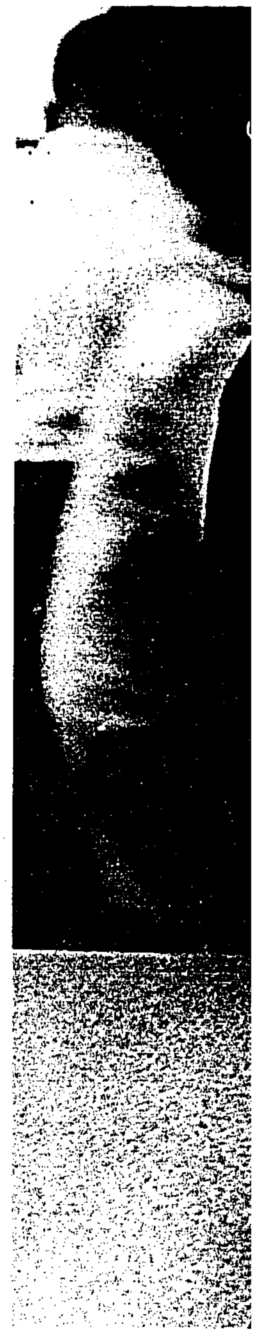

Cut here

Soil

As work on the plants progresses, the children will gradually get some sense of the factors necessary for healthy plant growth. They will discover the results of lack of light and lack of moisture fairly quickly. *What else do plants need?* Some students may be interested in comparing plant growth in water and in soil. They can grow some plants in damp paper towels or vermiculite and others in soil. They can grow some in sand, some in gravel, some in clay (even Plasticine), and some in good garden soil. *What differences are there? Do these differences become apparent immediately or do they take a long time to show up?*

One way in which garden soil differs from any other growing medium mentioned is that it contains decaying organic matter (humus). Perhaps someone will want to do research into the differences among various types of soil. It is interesting to note that most of the minerals that plants need have been dissolved out of beach sand by the action of the waves, so this sand is usually not very good for growing plants. Sand from a dry region still contains most of these minerals, however, and so may be excellent for growth.

The children may want to try adding things to water. *Will commercial plant food help the plants thrive on paper towels?* Remember that very little plant food is needed. Some children may be interested in seeing whether the chemicals in the plant food really kill the plants if used undiluted. *Will plants grow in liquid bleach? . . . ammonia? . . . vinegar? . . . detergent? Which grows better in water alone — beans or popping corn?*



Salt

What about salt? *Will plants grow in salt water? What if there is just a little salt? . . . a lot? What happens at the seashore?* If the children get interested in this question, they can begin to explore the complex ways by which plants and animals have adapted to their environments. Pond plants will die in seawater. Ocean plants, such as the kelps and other marine algae, will not survive in fresh water. Aquatic plants cannot live out of the water, while most land plants will not endure extensive flooding. Other plants have become specially adapted to brackish water, marsh, or beach environments. Of course, many parallels can be drawn to the conditions that different animals need for survival.

Temperature

One group of children investigated whether seeds would sprout outdoors in winter. Others tried freezing seeds to see whether they would sprout afterward. *Will sprouted seeds survive freezing? Will they live if placed on a radiator?* Some tree seeds must be frozen before they will sprout; others are killed by frost.

Water, Air, Other Gases

Children may want to see which plants will survive drowning or drought. *Will seeds sprout under water? Can plants live sealed up in a jar?* Children experienced in working with gases might want to try growing plants in an atmosphere other than air. (See the Elementary Science Study unit BALLOONS AND GASES.*)

Insects

Flies, aphids, or other insects may start growing on the plants or in the damp soil or vermiculite. Some children may want to find out more about these insects. Have them enclose the plants and insects in a large clear plastic bag or contruct a cage from netting and coat hangers or dowels. Can they find eggs of the insects? *What are the insects eating? How many wings have they? How many legs?* Suggest that the children look at dead insects under a magnifying glass or a microscope. Many books are available to help children identify and learn more about insects.†

*Available from Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011.

†The Golden Nature Guide. *Insects*, by Herbert S. Zim and Clarence A. Cottam is good for identification, though the selection of insects included is necessarily very limited. *Rearing Insects in Schools*, by R. E. Siverly (Wm. C. Brown Company Publishers, Dubuque, Iowa, 1962) has many useful suggestions about the care and feeding of a variety of insects.

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A Final Note

The direction this unit takes will depend on the variety and abundance of materials that you and your students supply and on the ideas that the children come up with. Sharing their ideas and their findings with one another and with you can lead them to new ideas and joint projects. You may, occasionally, want to interject another question or problem. You must use your own judgment as to when this would be useful.